



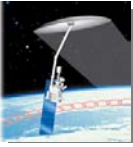
HYDROS: The Hydrosphere State Mission

A NASA Earth System Science Pathfinder (ESSP)

PI: Dara Entekhabi (MIT)

Applications Return: HYDROS Will Bring a New Era for the Capability to Predict Costly Natural Hazards (Extreme Weather, Floods, Droughts)

Initialization of the Soil Moisture State in Numerical Models Extends the Predictability of Processes Influenced by Surface Fluxes



The Cost of Natural Hazards

HYDROS

Hazards Mitigation Through Predictions: The Dividends of Understanding the Earth System

~ 30% of US GDP is in weather- and climate-sensitive sectors

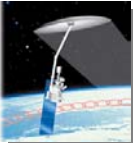
Dutton, J. (2002), *BAMS* 83(9), pp. 1303–1312.

Industries (1987 standard industrial classification)	Weather sensitive components (\$ billion)
Agriculture, forestry, and fishing	135.8
Farms	79.0
Agricultural services, forestry, and fishing	56.7
Mining	109.6
Coal mining	10.1
Oil and gas extraction	99.5
Other mining	0.0
Construction	463.6
Manufacturing	—
Transportation and public utilities	786.5
Transportation	
Railroad transportation	22.9
Local and interurban passenger transit	18.7
Trucking and warehousing	126.0
Water transportation	14.8
Transportation by air	93.0
Other transportation	0.0
Communications	281.1
Electric, gas, and sanitary services	230.0
Wholesale trade	—
Retail trade	893.9
Finance, insurance, and real estate	379.1
Security and commodity brokers	144.2
Insurance carriers	167.7
Insurance agents, brokers, and service	67.3
Other finance, insurance, real estate	—
Services	261.2
Hotels and other lodging places	86.5
Auto repair, services, and parking	93.9
Amusement and recreation services	80.8
All other services	—
Statistical discrepancy	—
TOTAL FOR PRIVATE INDUSTRY	3,029.6
Federal government	—
State and local government	829.5
TOTAL GROSS DOMESTIC PRODUCT	3,859.1

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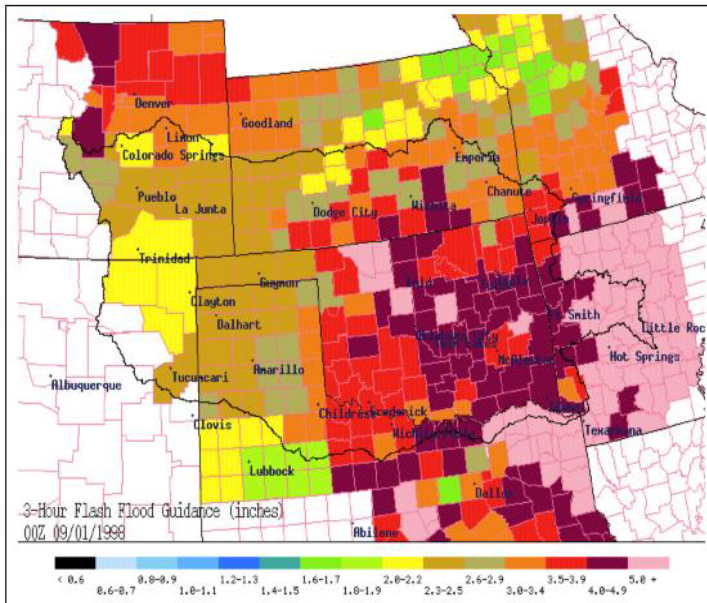


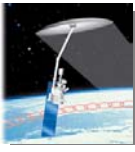


Direct Observations

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Current NWS Operational 30 km Flash Flood Guidance (FFG) is Formed Based on *Model* Surface Soil Moisture Deficit

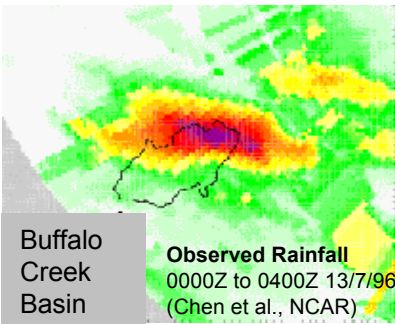




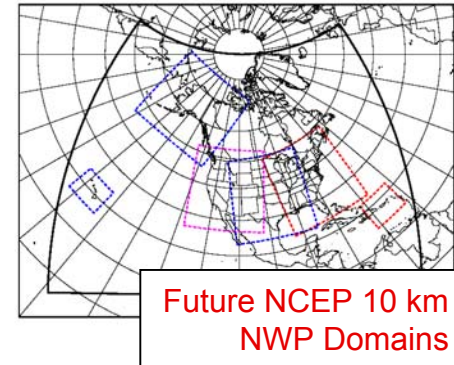
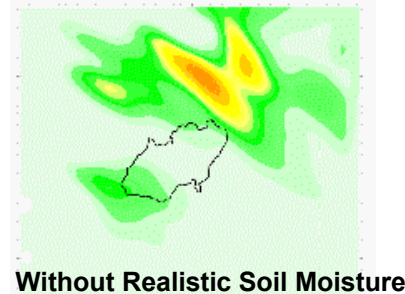
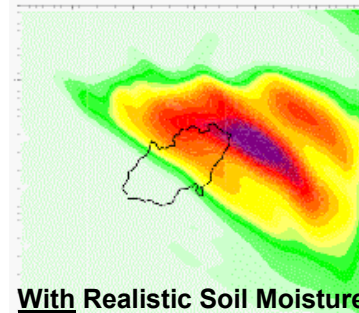
Application User Demand for Data

HYDROS

Initialization of the Soil Moisture State in Numerical Models Extends the Predictability of Processes Influenced by Surface Fluxes



24-Hours Ahead
Atmospheric Model
Forecasts



HYDROS Will Provide
L3_10km_SM Soil Moisture
Data Product Using Combined
Active and Passive
Measurements

HYDROS
Users

Collaborations:



Environment
Canada



"The experience of the last ten years at ECMWF has shown the importance of soil moisture...Soil moisture is a major player on the quality of weather parameters such as precipitation, screen-level temperature and humidity and low-level clouds."

Anthony Hollingworth, ECMWF

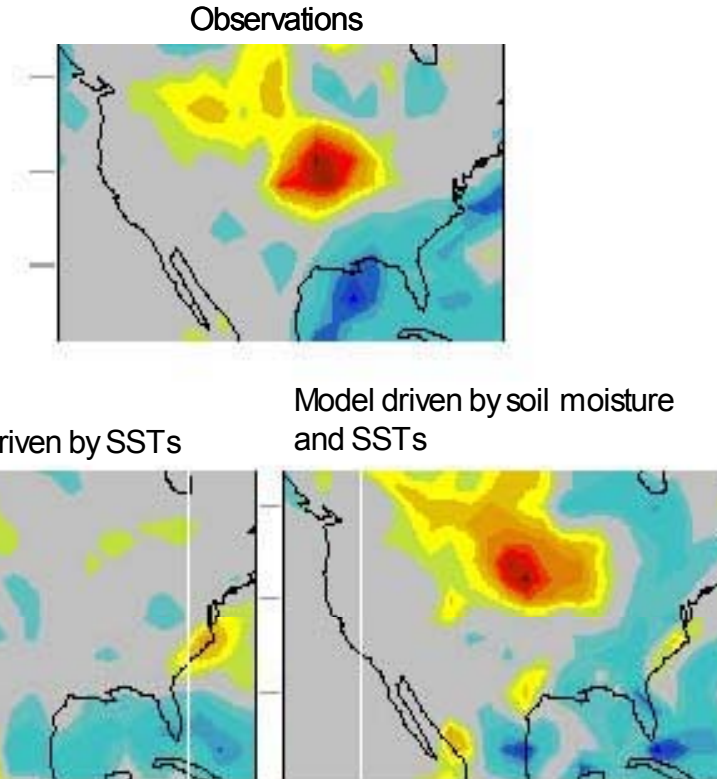
"The strong motivation for this land data assimilation and land-monitoring space mission such as **HYDROS** is that the land states of soil moisture, soil ice, snowpack, and vegetation exert a strong control on ...the heating and moistening of the lower atmosphere...forecast of tomorrow's heat index, precipitation, and severe thunderstorm likelihood."

Louis Uccellini, NCEP





Summer 1993 Rainfall Minus Summer 1988 Rainfall

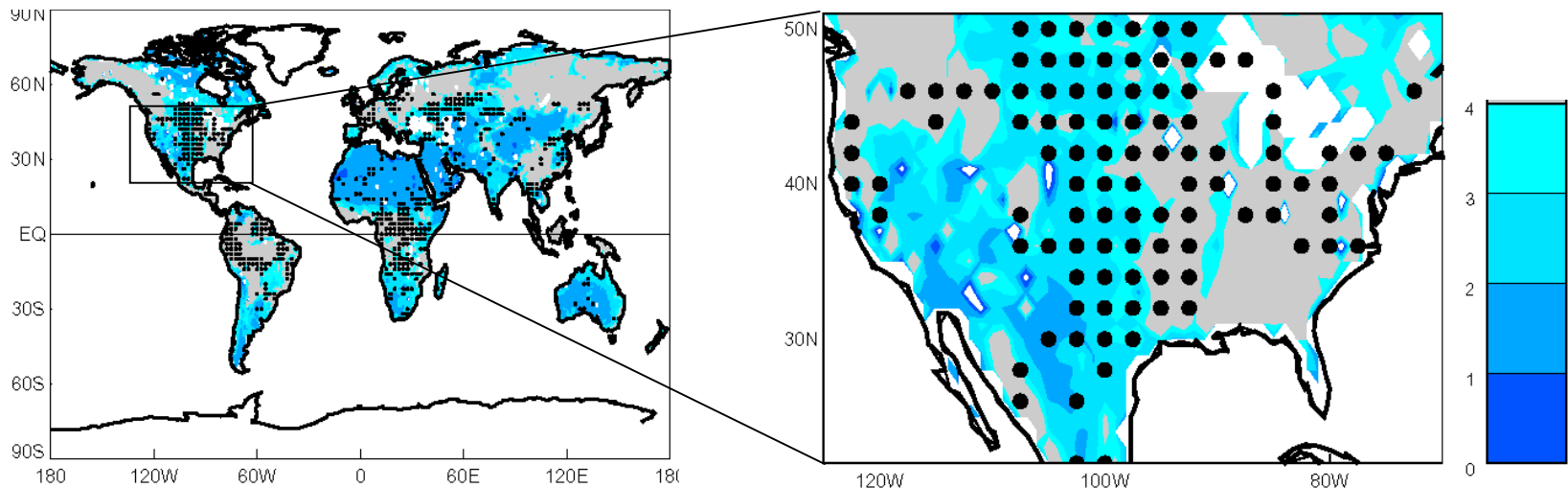


HYDROS data be used to extend seasonal climate predictability by incorporating land memory and land-atmosphere interaction processes in atmospheric models



L3_40km_SM HYDROS Product Retrieval Error Map (Blue Shades in % Volumetric; Gray >4% Requirement) and Regions Where Soil Moisture Has Significant* Impact on Seasonal Precipitation Predictability Through Land-Atmosphere Coupling (Dots Based on Modeling in Koster et al. 2003, *J. Hydromet.* 4[2])

HYDROS Can Map Soil Moisture Across Regions Where Soil Moisture Significantly Impacts Atmospheric Predictability



*At Least 1 in 5 Summers Affected in Model Simulations

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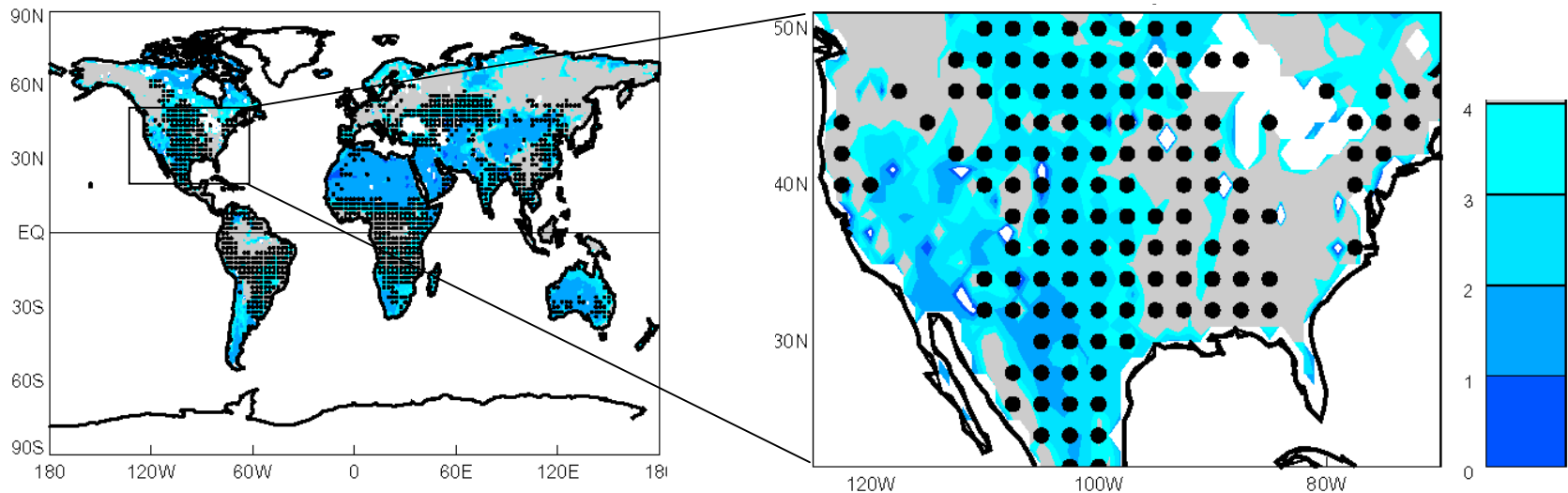
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[L3_40km_SM](#) HYDROS Product Retrieval Error Map (Blue Shades in % Volumetric; Gray >4% Requirement) and Regions Where Soil Moisture Has Significant* Impact on Seasonal Temperature Predictability Through Land-Atmosphere Coupling (Dots Based on Modeling in Koster et al. 2003, *J. Hydromet.* 4[2])

HYDROS Can Map Soil Moisture Across Regions Where Soil Moisture Significantly Impacts Atmospheric Predictability

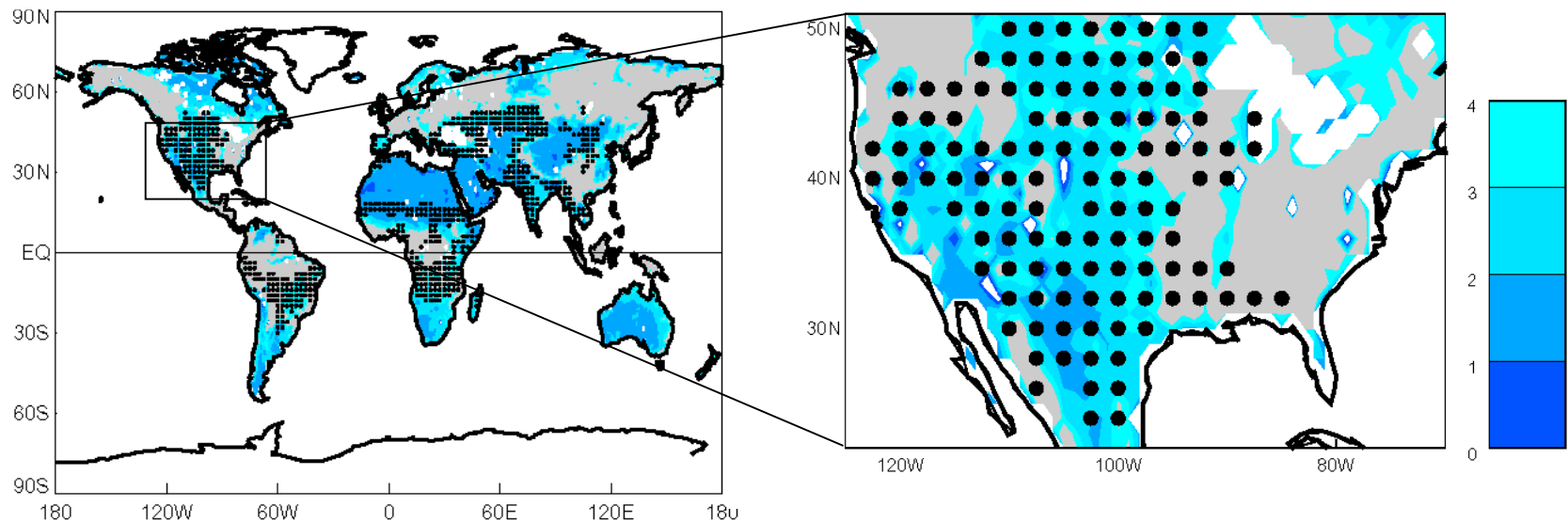


*At Least 1 in 5 Summers Affected in Model Simulations



[L3_40km_SM](#) HYDROS Product Retrieval Error Map (Blue Shades in % Volumetric; Gray >4% Requirement) and Regions Where Soil Moisture Significantly Controls* the Evaporation Rate (Dots Based on Modeling in Koster et al. 2003, *J. Hydromet.* 4[2])

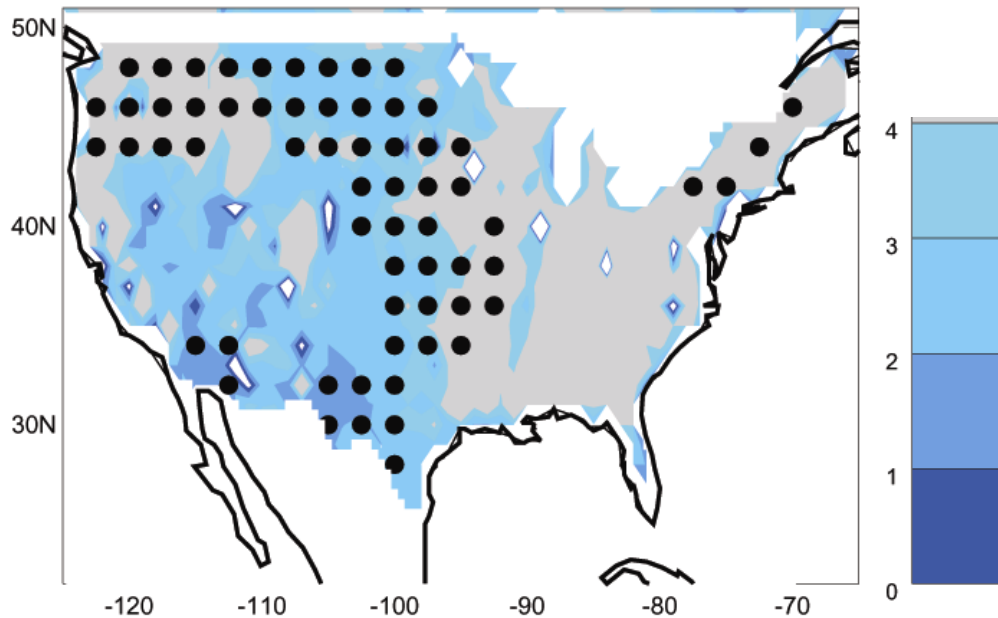
HYDROS Can Map Soil Moisture Across Regions Where Soil Moisture Significantly Impacts The Rate of Water, Energy, and Biogeochemical Cycles and Their Linkages



* 15 Wm⁻² Change in Latent Heat Flux for Every 10% Change in Soil Saturation



[L3_40km_SM](#) HYDROS Product Retrieval Error Map (Blue Shades in % Volumetric; Gray >4% Requirement) and Regions Where Soil Moisture Significantly Affects* Precipitation Persistence (Dots Based on Observational Study in Koster et al. 2003, *Geophys. Rev. Lett.* 30[5])



HYDROS Can Map Soil Moisture Across Regions Where Soil Moisture Significantly Impacts Memory in Precipitation

* Correlation Greater Than 0.8 for Pentad Precipitation Accumulations That Are Separated by Two Pentads



HYDROS: A NASA Mission That Supports DOD Forces and Addresses Their Identified Requirements for Tri-Forces

- Terrain Trafficability
 - Soil Moisture, Freeze / Thaw Data Are Required for Terrain Trafficability Assessment
- Fog and Visibility Forecasts
 - Soil Moisture, Freeze / Thaw Data Are Required for Fog and Visibility Forecasting
- All-Weather Sea Ice Mapping
 - New Measurements to Detect Ice Edge and Distinguish Between First- and Multi-Year Ice



New Weapons Systems (FCS)

- Wheeled Vehicles Replacement of Tracks
- Autonomous, Semi Autonomous Systems

New Concepts of Operations

- Fewer Forces
- Increased Dispersion
- Greater Mobility Required in Operations

**Terrain Trafficability Assessment Is
a Critical Element of Operations**



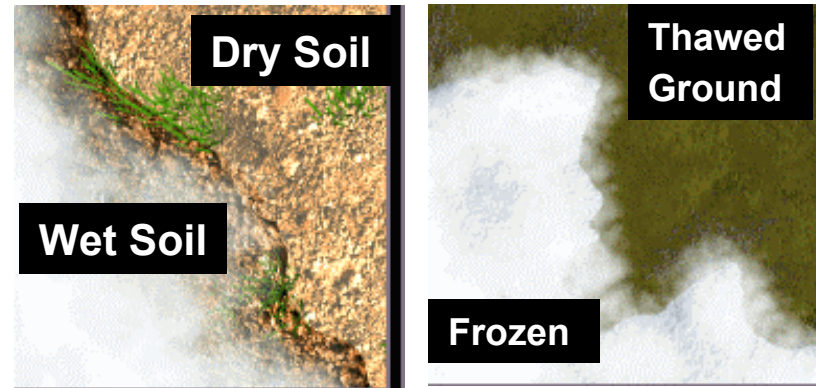
1991 Gulf War Illustration of the
Importance of Soil Moisture
Assessment



Increased Requirement to Operate Out of Smaller, Unimproved, Remote Air Fields

Greater Need to Predict Aviation Weather Over Land (e.g., fog and dust)

Improved Capability to Predict Target Movements Based on Trafficability Assessments



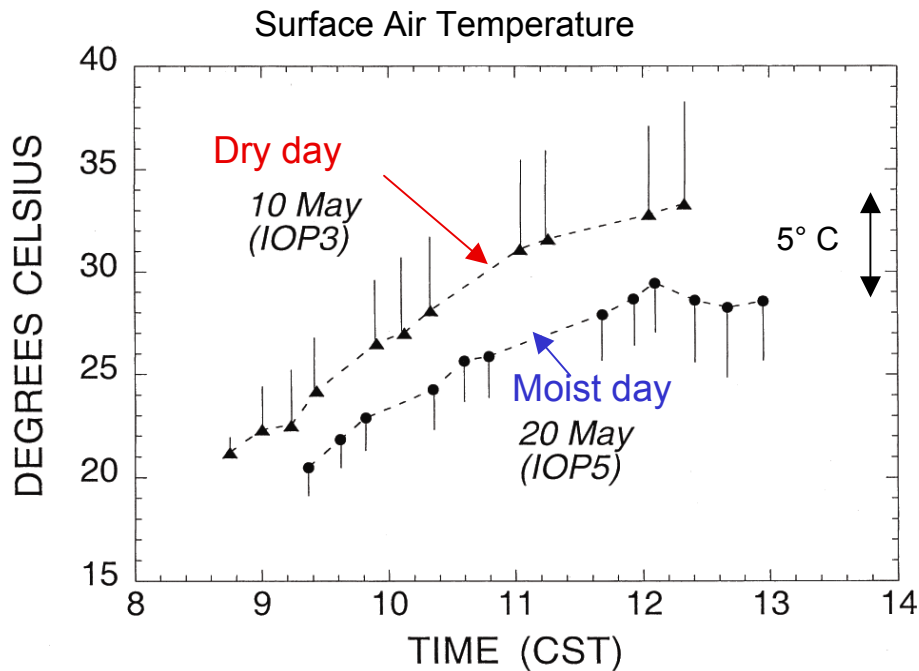
Fog Formation Over Wet Soils and Frozen Ground

Soil Moisture and Its Freeze / Thaw State Are Recognized to Be Critical Data Requirements for Weather Forecasts



HYDROS

Improved Weather Prediction: Ability to Predict Formation of Low Level Fog and Weather Factors Related to Takeoff and Landing



Measurements of daytime evolution of convective mixing – SE Kansas
Bulletin of the American Meteorological Society, 81(4) 757–780.



**HYDROS Will Be Making the
First Global and High-
Resolution Mapping of Soil
Moisture for Numerical
Weather Prediction (NWP)**

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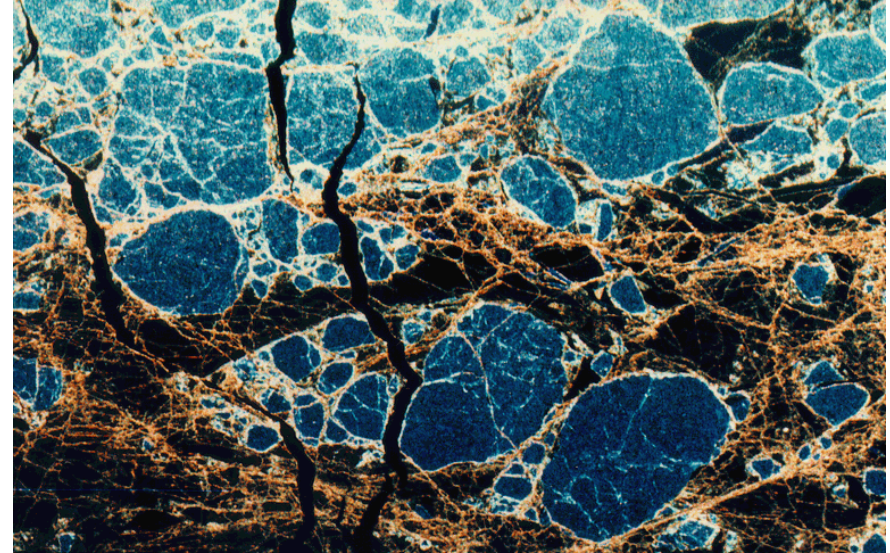


New Capabilities for Naval Operations

HYDROS

Operations in Polar Regions

Increased Requirement to Predict
Sea Ice Conditions (Age and
Extent)



First-Year and Multi-Year Ice in Beaufort Sea

HYDROS Significantly Enhances Current Ice Mapping Capability by Making All-weather (Clear and Cloudy) Daily Measurements at 1-3 Km in Arctic

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Summary

HYDROS

1. End-to-end pathfinder science mission:
 - Applications community is demanding the measurements.
 - NASA-DoD partner in national security.
 - HYDROS science is basis for a unique education activity.
2. Low risk technology: *Nothing new, just how we use it.*

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